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CONTENTS

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THE DUTY OF BIOLOGY[1]

In speaking of the duty of biology, I refer to the services which, as a science, it may reasonably be expected to render to mankind. We must regard the subject pragmatically, and value it for what it is worth. In order to do this, we must first determine what is of service to our species—to us as individuals, or to *Homo sapiens* generally, in the long run and the fullness of time. Contemplate the situation of a human zygote, soon after fertilization, about to float down the stream of time, and ultimately disintegrate, at least in a physical sense, at the age of say eighty-five years. At the very outset, it is closely circumscribed by its heredity, by which we mean the consequences of innumerable past events. It may be a very serious and dreadful matter if some ancestor mated with some one carrying a congenital defect. This lamentable occurrence may date from the time of Julius Caesar, or from last year. It may be a matter for great rejoicing if the various ancestors united high qualities and the newly formed zygote is in possession of the potentiality of genius. So much, then, for the heavy hand of the past, but what of its future? Being human, this zygote is enormously complex and extremely susceptible to various influences. It is subject to the power of choice, compelled to confine itself to the realization of only part of its numerous potentialities. It will reăct in the most subtle ways to phenomena which might seem to some outside observer of no possible consequence. The more highly it is developed, the more delicate its reactions, like those of the princess in the fairy tale, who was made uncomfortable by a pea under six mattresses. The science of the mind can not keep pace with these events; we classify and define them, but to understand them we should have to solve the puzzle of the flower in the crannied wall.

Evidently, biology has its limitations; but what can it, what should it, do for us? The human machine, like any other, is subject to mechanical laws. As conscious beings, our very bodies are in a manner external and objective, subject to the domination of our will. I once went through an automobile factory and watched the men at work. The power was provided, and the highly complex machines appeared at first to be working quite independently. One could almost imagine that automobiles would continue to

[1] Presidential address, Southwestern Division, American Association for the Advancement of Science, Phoenix, Arizona, February 15, 1926.

be produced indefinitely, if all the working staff went off on a holiday. But closer inspection showed each man watching continuously, and now and then putting his hand on some screw or lever, making all the difference between efficient production and failure. Still more striking was the great sugar factory at San Pedro de Jujuy, in Argentina, last summer. Here again, vast machines seemed to render ridiculous the ant-like creatures hurrying about them. But I was shown a certain process which required accurate judgment and instant action on the part of the operator; and if he failed the whole product was irreparably ruined. The analogy is not overdrawn, the error is doubtless on the side of moderation. In the sugar factory, the machines remain what they are for long periods of time, and very fortunately do not inherit all the defects of those in use a number of years ago. The sugar machinery is capable of being governed in perfectly specific and well-understood ways, but the human machine is influenced in ways we wot not of, and at times when it is not under observation. Who knows accurately what goes on in his own mind, let alone those of others? In short, so difficult is it for us to know what to do with ourselves that we might well ask for a simpler task, had we any option. History is full of records showing how catastrophe followed catastrophe, merely as the result of ignorance. A cynic might plausibly complain that mankind was like a player, compelled to play a game without being told the rules.

Obviously, the rules will not come to us by any simple process of intuition. They must be read in the book of nature, where they have always been waiting for the discerning eye. Many have already been clearly ascertained and ably set forth. This has been done by the informal committee of the scientific men of the world, working through many centuries, but most successfully during the last hundred years. Make a list of the real contributors to scientific knowledge, and it is pitiful to see how few they are. This service, the most important for every state and every individual, has been rendered by a handful of men, usually working under difficulties. Sometimes they were compelled to hide their light under a bushel, sometimes it was summarily extinguished by vandals. Surely mankind has not deserved the services of its benefactors, if we judge by the way it has behaved.

Yet this is by no means the worst of it. Children, old and young, often react to some delicate toy or instrument by smashing it at once. Sometimes they use it to smash other people. So it has happened that gifts of science have been wantonly misused and we sometimes wonder whether our species will not eventually exterminate itself as a result of knowing how. Thus, with enormous increase in the means of production, with facilities of transportation undreamed of a few years ago, with marvelous control over disease, we still have war and greed, to which these great services are actually made to minister.

We must all admit that the remedy for this state of affairs does not lie wholly in the scientific realm. Without a sense of human values, for which mechanistic science has no justification, we can attain no real virtue. Ultimately, all payments have to be made in the bank of consciousness, the operations of which can only be superficially described. Nevertheless, as a horseman desires a good mount, so we desire the means of riding through life without being trampled underfoot. Science, if asked, will provide this mount, at least if given sufficient notice ahead. Yet we, on our part, must learn to ride. Dropping all metaphor, it simply come to this, that scientific research must be promoted on the one hand and scientific education on the other, so that we may become, so far as it serves our purposes, a nation of experts.

Take, first of all, the promotion of scientific research, the enlargement of the boundaries of knowledge. What are we actually doing about it? If you examine a list of those foremost in biological science in America, you find that nearly all are teachers, executives or engaged in the routine of economic work. The output is of course very considerable, and of high quality; yet I believe neither quantity nor quality approach what should be easily possible. For the best results we need intensive, cooperative work, led by a master mind. These conditions have been fulfilled at Columbia University, and the result has been to raise a new structure of biological theory, the ultimate significance of which can hardly be overestimated. It would be absurd to pretend that this performance could be duplicated simply by creating favorable conditions, but it is not absurd to say that such conditions have much to do with the results. The average scientific man, as I know him, lives a fairly easy life, and as a man may fairly be envied. But his attention has to be directed to many things, his time is broken up and he suffers from the same sense of intellectual dissipation or disintegration which affects nearly every one on the campus. For many people this checkered mental life is not altogether a bad thing. Varied experiences, with a considerable proportion of failure, are normal for the young, who are beginning to learn. A good politician or a good college president needs to have a sort of acrobatic mentality, a capacity for being all things to all men at a moment's notice. Such gifts are of a very high order, as exhibited in a Roosevelt; but they do not make a Darwin. It is not a mere coinci-

ence that Darwin and Wallace, the two great prophets of evolution in the last century, were amateurs, outside the professional fold. So also was Herbert Spencer, who, however poorly he may have wrought in certain respects, left an indelible mark on the human mind.

There is no single or certain way to produce the most fruitful scientific research, but we can at least pay attention to the conditions under which it has been accomplished. Certain things appear essential; time—continuous, unbroken time, is assuredly one of them. The material means, such as books and specimens and apparatus, are taken for granted, or should be. Yet they are frequently not available, and in any case only the expert can properly assemble them. The stimulation of kindred spirits, and cooperation in general, are of fundamental importance. We think of Darwin as working alone, but his letters show what he owed to Hooker, Huxley and a host of correspondents. He cared little for public praise or blame, but very much for the critical understanding and appreciation of fellow workers. Read the lives of eminent scientific men, and it is remarkable how these birds of a feather flocked together. Mrs. Darwin, when recently married, may have found it a bit embarrassing to entertain at dinner the greatest botanist and the greatest geologist in Europe, but they were there by natural right. We are reminded of the phenomena of electricity, a spark resulting when two dynamic centers are sufficiently approximated. So it is with men, and if we want to see science prosper in our country, we must reach a certain density of scientific population. It is doubtful whether Shakespeare could have produced his great plays, except in a period of real appreciation for poetry, such as certainly does not exist to-day.

With all these conditions fulfilled, the work may still fail to become fruitful. It has to be recorded and made available or it is sterile. Leonardo da Vinci minutely studied human anatomy, but his incomparably exquisite drawings were not published until 1898, and his manuscript describing them appears to have been lost, though there are many notes. It thus remained for Vesalius to break the tradition of ancient authority, and create a new science of anatomy. Mendel's work on honey bees, which we should now regard as infinitely precious, was lost because after his death an assistant saved only the well-bound books for the convent library, burning the supposedly useless manuscripts. The plants of Captain Cook's first expedition, of which five hundred copper plates were actually engraved, were left unpublished until 1905, when partial publication was secured through the British Museum. By that time, of course, they had been rediscovered and made known by others. The history of science is full of instances in which good work has been done, and has come to little or nothing because of the failure to publish. It may be claimed, of course, that such failures do not matter much in the long run. Where Leonardo failed to publish, Vesalius succeeded. Plants that Banks and Solander did not make known were described by Robert Brown and others. But such arguments lose sight of the influence on contemporary thought, which is in its turn the means of further progress. In other words, if you delay your journey until to-morrow, and still push on with all possible speed, you will always be a day's march behind where you might have been. Another consequence, perhaps more serious, is the influence on the work itself. Who, to-day, will undertake a large monograph, not knowing whether it can ever be published? Who, again, will make his work fully intelligible by giving sufficient detail, when extreme condensation is needed in order to be able to present the most important things? It is quite true that many scientific writings have been made uselessly elaborate, with padding which represented little of value; but it still remains a fact that we are discouraged from presenting subjects in a broad way because of the restrictions on space. To give a concrete example, suppose we are describing a new insect from Arizona. The mere description will take a page or less, and will suffice to make the species "known," as we say. But if we added an account of the place where it was found, a general account of the genus to which it belongs, a discussion of the distribution of that genus, and a statement of the things we still wish to find out, the story might be made readable and interesting. No wonder that taxonomy is sometimes in disrepute, because unintelligible even to most of our colleagues. It is almost as if we used signs for language.

The southwest has largely depended intellectually on other regions. This must always be true in the sense that increasing cooperation makes for worldwide interdependence, no state or nation working in isolation. But in another sense it should not be true, for to attain this wide cooperation each unit must make its own full contribution. Much of our necessary work must be done on the ground; can not be done in museums a thousand miles away. We must interest our people in the advancement of science, of the science that lies close at hand, at our very doorsteps. If it is suitably presented, it will not seem so dull or incapable of being understood. We should be able to do our own work, and publish our results, or at least provide the means to have them published. We do not lack the funds, had we the will and interest. I suppose it is true that daily, in the United States, we waste enough to publish all the scientific work of a year.

The other side of our problem, that of general education in science, is no less beset with difficulties; but they are equally, I believe, capable of being met. In spite of all our schools and colleges, we have not yet created what might be called a scientific atmosphere. It is not altogether the fault of the public. The teaching profession itself has been and is in a state of perplexity regarding these matters, and sorely in want of an intelligent and well-supported program. Within the ranks of teachers I find two groups whose views seem to me harmful, having regard for the character of our civilization at the present time. One group consists of those who still cling to the old idea that science is only for the elect, and that a little knowledge is a dangerous thing. Such men are keen to train experts, and often render the highest services in this manner, but they do not desire to see the multitude scientifically trained. The other group includes those who abhor the technical or difficult side of science, and wish it made simple and easy. They think the aroma of science is enough, without the substance. These also often render good service by bringing simple ideas and conceptions to those able to assimilate them, as is sometimes done so efficiently in moving pictures. We should, then, have no quarrel with either group, were it not that the result of their combined efforts is to deprive the people of substantial scientific training. General science, given without laboratories by a teacher who is not expert in any particular branch, may have its uses at a particular stage in education. It is, however, no substitute for biology, chemistry and physics in the senior high school, with competent teachers and laboratory facilities. It is certainly true that scientific courses in high school and college have been criticizable for content and methods of presentation. The same criticisms are applicable to courses in mathematics, and for that matter to the old classical courses of the days when Latin and Greek were the backbone of the curriculum. I have not forgotten the absurdity of trying to memorize the list of kings of Israel or recite page after page of Ovid. Yet one has only to look at the now current text-books of biology to see how greatly the teaching of this subject has been reformed. It has assumed new and varied aspects, relating itself to innumerable human interests. In the hands of good teachers it is competent to enlighten the world and make the higher civilization a practical thing. It will enable us to see where we were blind, to sense the trends of progress and intelligently choose our leaders. Without it, we are abandoned to superstition, quackery and disaster, for nature gives no quarter to those who will not or can not play her game. Let us then resist to the uttermost those who would succumb to the great modern illusion, which teaches that we may have pictures without knowing how to draw, music without ability to play, science with only the simple conceptions of a child. This is the voice of barbarism, calling from the darkness of the past. Certainly, we must concentrate on the arts of presentation, and remember that learning does not cease on leaving school. Many matters, now regarded as hopelessly abstruse, may be made intelligible to the majority. Science must seek the aid of literature, even of poetry and the drama. Look at the poetry in the current magazines. Aside from its technical qualities, concerning which much might be said, how futile nine tenths of it is! It offers us for the most part the vapid sentiments of egotists, who are incapable of any higher emotion. Yet poetry has been and sometimes still is the vehicle for the expression of human thought in its highest forms. Let the dynamic ideas of science and their application to our affairs supply the content for new and virile verse, which may stir the minds and hearts of thousands! Can we, from out of our multitudes of ardent young folks, find a new Tennyson to do this great thing?

From these exalted conceptions, it seems ridiculous to pass to the question of compilations and indices; yet these are just as essential in their way. Even poems have to be classified and indexed, if we are to find them when wanted. When we speak of scientific research, we think of enlarging the boundaries of knowledge, but much of the energy of scientific men is necessarily spent in consolidating the gains already made. The Germans do this kind of work very well, and I, for one, am constantly indebted to their painstaking compilations. America, on the whole, is seriously behind in these matters. We have no general account of the fauna of the United States, not even a list of the species. In numerous groups, it is easier for me to determine a species from India, using the great Fauna of British India, than one from the Rocky Mountains. We have published many fine monographs, but they are for the most part expensive or difficult to obtain, or else are so purely technical that the beginner can not use them successfully. We of the west should shoulder our own burden, and prepare a really intelligible account of the natural resources of our region. This could not be done all at once, but it could be planned for, and developed by degrees, like a modern city. It might begin with a simple check-list, a sort of census of what was known, reduced to its lowest terms. Then, as workers were found, the flesh could gradually be put on these dry bones, and the subject made alive.[2] Such an undertaking would, from its nature, never be

[2] Warren's "Mammals of Colorado," written at Colorado Springs, is a fine example of this type of work. The author had to subsidize the publication.

complete. It is fortunate that it should be so, for the work itself is most worth-while, and through it we should attain, not merely scientific ends, but the moral virtues of fellowship and intelligent cooperation. As for the expense, it ought not to be necessary to mention such a thing.

I referred just now to the resources of the country, and I suppose some of you are wondering just what those include. Is our great undertaking to include simply the sources of food or shelter or clothing? Or if we include the flowers, is it only because they can be eaten by cows, or because innocent people will sometimes buy them, and so give them commercial status? I do not so understand it. We live in a great and wonderful environment, to which we may react in a thousand ways. Broadly speaking, happiness comes through the harmonious exercise of our faculties. To be blind where we might see, callous where we might feel, dumb where we might speak—these are the great futilities, in the presence of which material wealth is of small account. Thus we must hold that our resources are only limited to those things which we can appreciate with our senses, and get some good by so doing. Wealth of this kind is so abundant that there is more than enough for all. No one can use more than a small part of it, but many minds and hearts, with a common purpose, may approach a grand synthesis which some genius will clarify and define. This is the manner of intellectual progress.

In this country of ours we are facing a somewhat new situation. Thanks to science, material wealth has increased enormously. With the spread of democratic ideals, life has become easier, the hours of labor shorter. People have time and money as they never had before. What are they doing with them? We have only to look around to see resources wasted, and time—the precious hours and minutes of human life—squandered on inanities. We do know how to work, the whole world admits that, but we do not know how to play. Now with the pressure of a complicated civilization and the dominance of machinery, our working hours are more and more standardized as to their content and the manner of our operations. We are necessarily slaves to the system or to the machine. This is no great evil, so long as it occupies only part of our time, and we have still enough in which to dream, and invent, and discover. But if the free time, the so-called leisure time, is deprived of worthy activities, not only is life reduced to its lowest terms, but the very springs of progress are dried up. Thus the appreciation of nature, including human nature, becomes a high social duty, through which personal happiness and national progress may be attained.

And, after all, even in those dark valleys of sorrow and loneliness which we all have to cross, there comes the sense of the unity and permanence of this wonderful universe, in which loss is followed by gain, apparent death by resurrection; and we, atoms that we are, are partners in the firm which shall never be dissolved or go into bankruptcy. Vital activity is our business, and through it, in all its varied forms, we may realize the purpose of existence. Putting the thought in verse, we may perhaps express ourselves in this wise:

The world is full of sorrow, and sad the heart of man,
Put on the bright and merry tune, and dance it if you can,
And let it be a token, that in ages yet to be
The flowers will blossom in the fields, the glory of the sea
Will never fade or pass away, nor will the changing sky
Its lovely pageant fail to show, as hours of daylight die.

So banish man-made ugliness,
Let vulgar notions fade,
And learn to know the loveliness
Of that which heaven made!

T. D. A. Cockerell
University of Colorado

NOTES ON THE AIRY OR "ROOTS OF MOUNTAINS" THEORY

The Pratt theory of isostasy calls for a uniform thickness of the crust or, at least, it is supposed that the crust extends to a uniform depth below sea level.

The Airy theory, on the other hand, postulates a varying thickness. This is practically identical with what is generally called the "Roots of Mountains" theory and we shall therefore speak of the two as the "Roots" theory.

In the Pratt theory the major, and perhaps other, changes in elevation must be due to changes in the density of the materials of the crust below the affected surface. The changes in density may be uniform throughout the crust, they may be greater at one depth than at others, or they may affect only a part of the crust. Although we may prove the Pratt idea by geodetic and other evidence which might be available, it is possible that we shall never be able to determine the exact distribution, with the depth, of the changes in density resulting in the formation of a mountain system or a synclinorium.

Isostasy seems to have been proved. Just how the densities of the crust are arranged to give the equilibrium, found to exist, and how the equilibrium is maintained are interesting problems still unsolved.

In this short paper let us lay aside the Pratt idea and give our attention only to the Airy or Roots theory. I am assuming the rôle of an advocate of

the Pratt idea and consequently am setting forth some of the weaknesses of the Roots theory.

The Roots theory calls for the crushing of the crustal material to form mountains and islands. To account for the elevation of a plateau, such as the one to the east of the Rocky Mountains in North America, there must have been an uplift due to the thickening of the crust. This could only have been due to pressure from the sides and must have been accomplished without distortion of the outer strata which, through erosion, can now be seen and examined.

I do not recall having seen, in the literature on the subject, just how a synclinorium is formed under the Roots theory, but it must be due to the reverse of the process involved to cause a major uplift if the isostatic equilibrium is to be maintained.

The conception of the Roots theory is due to the belief that the nucleus of the earth is losing heat and contracting, while the crust, maintaining its temperature, collapses on the nucleus. The theory calls for a constancy of the crustal temperature. Another essential feature of the theory is that there are no decided changes in density of crustal material.

A condition of the earth made necessary by this theory is that the subcrustal materials must be very weak in order to permit the buckled crust to extend downward into it. The crust, on the other hand, must have very weak material along certain belts where the breaking, crushing or plastic yielding takes place to form the mountains. The remainder of the crust must be strong enough to carry the thrusts for thousands of miles to the yielding belts, overcoming the frictional resistance to the crust moving over the subcrustal matter. The crust must be weak enough to undergo the distortion incident to the concentration of the crushing or buckling within narrow zones of moderate length as compared with the earth's circumference.

These seem, at least, to be some of the conditions which must be present in the crustal and subcrustal material, in order that the Roots theory may function. Let us analyze just a few phases of the problem involved in the processes which must be operating under the Roots theory.

Seismologists and students of the earth and ocean tides, as well as those engaged in a study of the variation of latitude, tell us that the earth as a whole is as rigid as steel to the short-time stresses with which they deal. It is necessary, therefore, to give up any ideas that the subcrustal materials are highly plastic to short time stresses.

But, in spite of its high rigidity shown under the short time stresses, we know that the crust of the earth is in isostatic balance to a remarkable degree of perfection. In order that this may be true, the ability of the subcrustal materials to resist the gravitational stresses set up by the shifting of materials over the earth's surface must be exceedingly small. Evidences of tremendous erosion are everywhere present on land areas, yet the existence of the isostatic equilibrium is established by geodetic data.

Such a low residual rigidity of subcrustal material is needed by the Pratt as well as by the Roots theory. The first requires a horizontal movement below the crust to restore the isostatic balance, while the second must have a pushing down of the crustal material into the subcrustal space with horizontal movement of displaced matter. But this weakness which must exist makes it certain that the subcrustal matter acts hydrostatically under any stress differences which tend to disturb its equilibrium.

The Roots theory calls for a crushing of the crustal material or for at least a giving way of the material plastically along certain belts, with the consequent elevation of the crustal surface and the depression into the subcrustal space of a protuberance several times the surface change in elevation. The relation of the elevation of the surface and the depth of the roots depends upon the relation of the crustal and subcrustal densities. This formation of mountains and roots requires a crustal material, along the crumpled line or zone, of great plasticity or of low strength. The distortion must be due to either plastic flow or crushing. But the subcrustal materials must be even weaker than those of the affected part of the crust.

Under these conditions is it possible that the root can maintain itself against the hydrostatic pressure of the subcrustal matter exerted against the sides and bottom of the root?

Let us consider the root or roots of the Himalayan Mountains. The average elevation of the Himalayas is not far from three miles. The root must be extensive enough to counterbalance this mountain mass. If the subcrustal material is assumed to be ten per cent. denser than that of the crustal matter forming the root, the downward extension must be about thirty miles. The stress exerted by the plastic subcrustal material on the tip of the root must be equivalent to that exerted under gravity by a column of rock three miles in height. Even though the root may have been formed, and it must have been of very weak material to have been formed, surely it could not be maintained against such enormous stress differences acting since the time the Himalayas were raised.

The condition of stresses under the Himalayas, by this theory, must exist under all mountain systems but only to degrees proportionate to their average elevations.

In applying the Roots theory to the elevation of a plateau, we run into the difficulty of having the crust so weak as to permit of great uniform thickening and at the same time so strong as to cause that thickening. It may be conceivable that the crust is strong enough to cause a thickening in a local zone, but how can material that has once carried a thrust great enough to thicken the crust several miles under the local zone be weak enough to undergo collapse and thickening itself under continuing horizontal forces? Or, if a local zone has been thickened on the side of the affected crust from which the thrust comes, how can that collapsed zone transmit further thrust to regions beyond it? Even though all this were possible, how can we account for the thickening of the crust represented by the elevation above sea level and the length of the roots, with at least the surface strata horizontal and apparently undisturbed, except for change in elevation? I can not recall having seen any explanation of how the plateau would be raised under the Roots theory, but the difficulties appear to be unsurmountable.

A theory advanced to account for the elevation of the earth's surface must also provide an explanation for a lowering of the surface. There have been synclinoria formed where were once high lands. The only process involved must be one of stretching. But would the stretching occur in the thick crust under a mountain or in the thin crust under an ocean?

It does not seem possible for a synclinorium to be formed under the Roots theory, for it has no provision for a change in the density of crustal materials. Without that provision we run into great difficulties.

If the crust is thick under the mountain systems, then under the deep portion of the oceans it must be thin. Under the portions of the oceans of average depth, it must be thinner than under the mountains. All this must be so in order that the Roots theory may be of universal application.

The theory calls for a very plastic subcrustal material, with a stronger material in the crust. Can we assume that the crustal material under the oceans, not more than half the thickness of that under the continents, is so much stronger that it can carry the forces without yielding or fracturing to the margins or interior of the continental areas and form mountains?

Considered as an engineering structure, placed in a testing machine, we should expect the failure to come under the deepest portions of the oceans where the crust must be thinnest.

How, for instance, could the Japanese Islands have been formed by horizontal thrusts from the continent outward, or by thrusts originating under the Pacific, in view of the fact that one of the deepest ocean troughs lies parallel to and not far from the Japanese archipelago on the Pacific side? The statement of the problem at once indicates the answer. It could not have been done in the manner indicated. The Roots theory seems to fail here if the crust under the deep is in isostatic equilibrium. Let us hope that gravity observations may be made over this and other deeps in the near future.

It is not practicable to use the Roots theory with any satisfaction in making the isostatic reductions of gravity stations or computing deflections of the vertical. This theory has, as a fundamental principle, constancy of density in the crust. The density may vary with the depth, but no change in the density of crustal material is supposed to occur during the process of the formation of the mountains and their roots. In order to use the theory some approximation to the differences of crustal and subcrustal densities would be needed. The difference in elevation between the highest mountain and the deepest point of the oceans is about ten miles. The difference in the thickness of the crust under these two places necessary to maintain isostatic equilibrium would have to be eighty miles with none of the crust under the ocean deep if the difference between crustal and subcrustal densities is ten per cent. In making the estimate of eighty miles rather than one hundred miles the mass of the water is considered.

The depth of compensation derived for the area of the United States from gravity data in mountainous regions is sixty miles. When the data for the whole area were used, the derived depth was found to be about forty miles. The depth for the United States from deflection data in mountain regions was about sixty miles and from data for the entire area the depth was about seventy miles.[1]

Taking these depths in connection with the Roots theory means that, if mountains have thick crust below them, the deeps of the oceans have below them no crust whatever. That is, the material would not be the same as found under continents. It would have to be the same in density as the subcrustal matter under the continents. Of course, subcrustal matter brought up to the bottom of the ocean might change its rigidity and strength from its normal condition, due to decrease in pressure and to lower temperature.

We can not now say, positively, that the geodetic data disprove the Roots theory, but certainly we shall have to formulate that theory in a somewhat different

[1] It is probable that the depth to which crustal material extends is somewhat greater than the computed depth of compensation. This idea is discussed on p. 39 of Special Publication No. 99 of the U. S. Coast and Geodetic Survey.

way from that usually outlined in order that a definite test may be made. As the theory is generally understood, analysis seems to indicate great weakness in it.

The hypothesis formulated by Wegener is closely related to the Roots theory. Isostasy is an essential part of it—but not the Pratt isostasy. According to this hypothesis, material of which continents and islands are formed, called *sial*, floats in a highly plastic material called *sima*.

The hypothesis has many strong advocates and as many equally strong opponents. It would take too much space even to outline the views of the two groups.

This much may be said, however: The mechanics of the hypothesis are weak to the point of being impossible. The sial, according to Wegener, was all grouped together in one body in the geologic past; then, under the exceedingly small stress differences caused by the tidal forces of the sun and moon, the mass broke into pieces and formed separate continents and islands. This may or may not have been possible. But when the drifting continents had their forward margins crumpled up into mountain systems by the resistance of the sima in which the masses of sial were moving, under small forces, there seems to be much mystery involved in the process.

The biological necessity for all the land movements postulated by Wegener may be present, and his theory may account adequately for the distribution of plants and animals. His theory would have had fewer opponents if he had left out the mountain-forming part of it.

Perhaps it will be found, upon analysis, that the meteorological conditions near the interior area of the unified mass of sial were not favorable to the growth of plants and animals whose remains, deposited in geological periods prior to the splitting up, have been found in parts of the drifting fragments which were far inland when the masses were together. It would seem that the central area of the combined sial would have been very arid and thus not suitable for much of the plant and animal life existing then.

The changes of density needed in the Pratt theory of isostasy may appear to many to be improbable, but if it is granted the mechanical details involved in uplift and down-warping of the earth's surface seem to be reasonable. Vertically acting forces as the predominant ones, with horizontal movements within the crust near the surface as secondary, seem to the writer to explain surface changes better than the regionally acting forces. But the former requires changes in density of crustal materials to maintain isostatic equilibrium.

WILLIAM BOWIE

U. S. COAST AND GEODETIC SURVEY

IRA OSBORN BAKER[1]

IN noting the death of Ira Osborn Baker, which occurred November 8, 1925, it is fitting that the senate of the University of Illinois place on its records a statement in recognition of the long and distinguished service which Professor Baker rendered to the university.

Starting as assistant in civil engineering and physics immediately upon graduation with the class of 1874 (the third class to be sent out by the university), in 1878 he was made instructor and was also put in temporary charge of civil engineering upon the resignation of the professor of civil engineering. In 1879 he was promoted to assistant professor in charge of civil engineering, and in 1880 to professor of civil engineering. With the establishment of departmental organizations in the university in 1892, Professor Baker became head of the department of civil engineering and continued in charge of the department until 1915 when he relinquished the administrative duties, but continued full teaching work. He again carried the administrative work of the department from 1920 to 1922. He was made professor emeritus in 1922, but continued to give service to the university in various ways until his death. During all these years he labored diligently and effectively in the upbuilding of the university. He exercised an important influence on university affairs in the accrediting of high schools, in the work of committees and in various other ways, especially during the earlier and formative period of the university. His greatest contribution was toward the development of the college of engineering and the department of civil engineering. Here through his teaching ability and his high ideals in instruction and in the aims and meaning of education and his insight into the needs of the profession of engineering, he aided greatly in giving early reputation to the college of engineering and in making its standing far higher than the number of students and the financial resources of the institution warranted. He early developed one of the first college laboratories for investigating the properties of cements, mortars and concretes, and a few years later one for highway materials. The designing, construction and equipment of the astronomical observatory were under his charge. Through his text-books and writings he carried his teaching to many engineering schools, even instructing the practicing engineer of the office and field all over the country. He was a leader in professional engineering activities and educational movements. Forty years ago he formed the Illinois Society of Engineers, an organization that

[1] Minute presented to the president and senate of the University of Illinois by a committee consisting of M. S. Ketchum, A. P. Carman and A. N. Talbot.

has had a considerable influence on engineering in the state. He conceived and organized the division of engineering education of the International Engineering Congress of the World's Columbian Exposition in Chicago in 1893, and is counted as the founder of the Society for the Promotion of Engineering Education, which was organized at the time of this meeting. His acquaintance and influence among engineers was country-wide.

Professor Baker's great work was as a teacher. Holding high ideals of the service that the teacher should render the student and having exalted views on the meaning and purposes of education, he exerted a great influence on a long line of students, his interest and his inspiration to them continuing through the years. His activities and service were given generously to church and community. A man of ability, character and personal charm, a teacher noted for instructional ability and influence on students, Professor Baker's fifty years of distinguished service to the University of Illinois deserve high commendation as contributing in a large degree to the work and usefulness of the institution throughout the first half century of its existence.

The committee recommends that the foregoing note be spread on the records of the senate and that a copy of it be sent to Mrs. I. O. Baker, and to Cecil F. Baker, Ira Webster Baker and Imo Baker Bent, children of the deceased.

SCIENTIFIC EVENTS

ELECTIONS OF THE ROYAL SOCIETY OF EDINBURGH

THE following candidates for fellowship have been recommended by the council for election as fellows of the Royal Society of Edinburgh:—

Braid, K. W., professor of botany, West of Scotland Agricultural College, 6, Blythswood-square, Glasgow; Cameron, A. E., professor of zoology, University of Saskatchewan, Saskatoon, Canada; Gardner, J. D., chief assistant to Messrs. D. and C. Stevenson, civil engineers, Edinburgh, 23, Ivy-terrace, Edinburgh; Harrower, J. G., professor of anatomy, King Edward VII Medical College, Singapore; Harvey, W. F., director, Central Research Institute (Government of India), 11, Learmonth-gardens, Edinburgh; Khastgir, S. R., research worker, University of Edinburgh, 1, Pilrig-place, Edinburgh, and Khastgir Lodge, Giridih, Behar, India; Lorraine, N. S. R., resident medical officer in charge of City Hospital, Hull; McBride, J. A., rector of Queen's Park Secondary School, Glasgow; MacKichan, D., formerly principal of Wilson College, Bombay, 18, Douglas-crescent, Edinburgh; Mekie, D. C. T., headmaster, Bristo Public School, 11, Minto-street, Edinburgh; Morris, J. A., Savoy Croft, Ayr; Patton, D., lecturer in botany, Glasgow Provincial College for the Training of Teachers, 9, Thornwood-gardens, Glasgow; Prashad, B., superintendent, Zoological Survey of India, Indian Museum, Calcutta; Roberts, J. A. F., research assistant on the staff of the Animal Breeding Research Department, University of Edinburgh; Romanis, W. H., surgeon to St. Thomas's Hospital, London, 31, Harley-street, London, W.1; Seton, Col. Sir B. G., Indian Medical Service (retired), 12, Grosvenor-crescent, Edinburgh; Small, J., professor of botany, Queen's University, Belfast, Ardcolm, Knock, Belfast; Stokoe, W. N., chief chemist and works manager, Craigmillar Creamery Company, Ltd., 67, Inchview-terrace, Edinburgh; Thomson, G. H., professor of the theory, history, and practice of education in the University of Edinburgh; Thomson, J., lecturer in plant physiology in the University of Glasgow, 17, Lothian-gardens, Kelvinside, N., Glasgow; Wakeley, C. P. G., lecturer in anatomy, King's College, London, 5, Devonshire-place, London, W.; Williams, S., lecturer in plant morphology in the University of Glasgow, 14, Caird-drive, Partickhill, Glasgow.

WORK OF THE INTERNATIONAL EDUCATION BOARD

THE International Education Board has issued its annual report covering work of the board from June 30, 1924, to July 1, 1925. During this period the board has provided traveling fellowships which enabled forty younger men of demonstrated capacity for fundamental research to spend a year or more abroad working under the master from whom they had most to gain. During the year covered by the present report, ninety-nine additional fellowships of the same character were awarded, and sixteen fellowships previously granted were renewed. The following analysis of fellowships provided between June 30, 1924, and July 1, 1925, indicates the international character of the program: Austria 3, Czecho-Slovakia 2, England 2, France 6, Germany 16, Holland 9, Hungary 10, Italy 2, Norway 3, Poland 8, Russia 8, Scotland 2, Serbia 1, Spain 1, Sweden 2, Switzerland 4, United States 20.

Seventeen countries are represented and, by coincidence, the courses of study undertaken by fellowship holders will be carried out in seventeen different lands, though the two lists vary to some extent.

The average age of fellowship holders is under thirty. Almost invariably, before appointment, they have obtained the higher academic degrees, and they have given evidence of an exceptional ability to pursue fundamental research. The fellowship is intended to provide a richer background of scientific experience than a man can obtain in his own country. It is intended that this experience will inure to the benefit of the fellowship holder, the institution to which he expects to return, the country to which he belongs, the country to which he resorts and the particular science to which he has devoted himself.

In a limited number of instances the board has made it possible for distinguished scientists to travel to other countries, not for the purpose of completing their training by a period of concentrated study, but in order to meet their colleagues of equally advanced standing, and exchange professional experience as it relates to problems and technique. Appropriations have also been made to enterprises or institutions of international importance. The sum of $35,000 was contributed toward the cost of preparing and publishing a set of International Critical Tables, under the direction of the National Research Council of Washington. The board likewise agreed, for a limited period and in a limited amount, to underwrite the publication of the proceedings of the London Mathematical Society. Six hundred thousand Danish kroner were appropriated toward the enlargement and consolidation of related departments under an Institute of Zoöphysics at Copenhagen, Denmark. Two grants of $10,000 each were made to the Junta para Ampliación de Estudios Cientificos at Madrid—one for the purchase of equipment urgently needed, the other toward maturing plans for the development of an Institute of Physics and Chemistry. The needs of the Institut für Radiumforschung at Vienna, and its importance as a center of physical research for southeastern Europe, explain an appropriation for the purchase of necessary supplies and apparatus. Similarly, a contribution of $3,000 was made to the Rijks University at Utrecht toward special equipment for physical research. In all these cases the board gave consideration not only to the requirements of the institution as such, but also to the relative rank which the institution has attained in its field. Other appropriations were made for the promotion of agriculture.

THE CHICAGO MEETING OF THE AMERICAN ELECTROCHEMICAL SOCIETY

THE American Electrochemical Society will hold its annual convention at the Chicago Beach Hotel, April 22, 23 and 24. The local committee on arrangements includes the following members: Dr. H. C. Cooper, *chairman*, Professor S. C. Langdon, *secretary*, R. G. Bowman, William Bray, E. W. Engle, W. R. Fetzer, Edward Gudeman, William Hoskins, G. H. Jones, W. Bartlett Jones, H. N. McCoy, H. T. McKay, A. F. McLeod, George R. Mitten, W. W. Murray, A. J. Weith and Fred E. Winslow. The committee has been active in arranging for what promises to be a successful meeting.

The main attraction of the technical program is a symposium on chlorine of which Mr. D. A. Pritchard is chairman. For many years there has been an overproduction of chlorine in the electrolytic chlorine industry and manufacturers throughout the world are interested in finding new uses for the gas. Besides the technical papers in the chlorine symposium, there will be a number of papers dealing in particular with the scientific aspects of the chemical and physical characteristics of chlorine.

On Friday morning the retiring president of the society, Mr. F. M. Becket, vice-president of the Electrometallurgical Corp., will deliver an address on "Modern Requirements in the Education of an Engineer." Following this address, the meeting will be devoted to miscellaneous electrochemical papers. The Saturday morning session of the meeting will be devoted to papers on electrolytic refining and plating of metals.

The luncheon Thursday noon will be devoted to round table discussions: one on the selection of proper plating metals, at which Mr. F. J. Liscomb, of the Hanson & Van Winkle Company, will preside; the other on comparative merits of electric and fuel-fired furnaces, in charge of Mr. Wm. J. Priestley, of the Electrometallurgical Corp.

There will be two general lectures. On Thursday evening Mr. Wm. J. Orchard, of Wallace & Tiernan, will speak on "Chlorine in Sanitation." On Friday evening, Major Rufus W. Putnam, U. S. District engineer, Chicago, will lecture on "Industry, Transportation, and City Building." The lecture by Major Putnam will follow a joint dinner of the American Electrochemical Society with the Chicago Section of the American Chemical Society.

The Local Committee has also arranged for visits to industrial plants in the vicinity of Chicago. It is planned to spend half a day at the Hawthorne Works of the Western Electric Company, and to visit the great Crawford power plant of the Commonwealth Edison Co., and the large modern Koppers Bi-Product Coke Plant.

CHEMISTRY AT NEW YORK UNIVERSITY

PROFESSOR JAMES KENDALL, of the department of chemistry of Columbia University, has accepted an offer from New York University to assume the position of administrative head of the department of chemistry in the Washington Square College of the University. The introduction of courses in chemistry in Washington Square College was made only during the last few years, but under the direction of Professor W. C. MacTavish the department has shown rapid growth so that a reorganization and extension, both of the laboratories and of the teaching, have been necessary. It is now planned to amplify the undergraduate courses in chemistry at present given at Washington Square College. The courses offered, in conjunction with the graduate courses at University Heights, will accommodate not only college and preprofessional students, but also more advanced workers in the science, such as students for the degrees of

B.S. and A.M. in chemistry and research workers for the degree of Ph.D., as well as students in the school of education.

Professor Kendall was born in Surrey, England, on July 30, 1889, and received his early training at the University of Edinburgh. He was appointed instructor in chemistry at Columbia University in 1913, assistant professor in 1915 and professor in 1922. He is the author of over sixty papers in the field of inorganic and physical chemistry and also of revisions of a number of the text books written by the late Professor Alexander Smith.

Professor Kendall will be accompanied to his new post by Dr. Eric R. Jette, of Columbia, who will assist in the further development of undergraduate instruction and of graduate research, with the rank of assistant professor. Dr. William West, of Edinburgh University, who has been research assistant to Professor Kendall during the past year, will also make the transfer to Washington Square College, where he will hold the rank of instructor. Professor MacTavish will continue in his position as director of the chemical laboratories.

SCIENTIFIC NOTES AND NEWS

THE American Philosophical Society will hold its annual meeting in Philadelphia on April 22, 23 and 24, under the presidency of Dr. Charles D. Walcott, secretary of the Smithsonian Institution. The annual dinner will take place at the Bellevue-Stratford Hotel on the evening of April 24.

DR. GEORGE L. STREETER, of the department of embryology, Carnegie Institution, has been elected president of the American Association of Anatomists. Other officers elected are: *Vice-president,* Professor Stephen W. Ranson, Washington University, St. Louis; *secretary and treasurer,* Dr. Lewis H. Weed, the Johns Hopkins University. Members of the executive committee: Professor George W. Conner, University of Rochester, and Professor Edmund V. Cowdry, Rockefeller Institute.

THE Association of the Alumni of the College of Physicians and Surgeons in New York gave a dinner on March 19, at the Waldorf-Astoria, in honor of Dr. William H. Welch, director, School of Hygiene and Public Health, the Johns Hopkins University. Dr. Welch spoke on "Reminiscences of the College of Physicians and Surgeons in the Seventies."

DR. WILLIAM P. MASON, for fifty years professor of chemistry at Rensselaer Polytechnic Institute, was the guest of honor at a dinner of the Rensselaer alumni at the Hotel Biltmore, New York, on February 6. Dr. Mason recently retired from active service with the institute.

PROFESSOR CAMILLE MATIGON, professor of mineral chemistry at the University of Paris, has been elected a member of the French Academy of Sciences, in the section of chemistry, in the place of M. Haller.

DR. A. C. SEWARD, professor of botany at the University of Cambridge and vice-chancellor of the university, and S. L. Pearce, commissioner of electricity at Manchester, have been recommended for the honorary degree of doctor of science at the University of Manchester.

PROFESSOR GOSIO, of the Italian public health service, has been awarded three distinct prizes, according to the Italian correspondent of the *Journal* of the American Medical Association; the first prize of the Pagliani Foundation (5,000 liras and a gold medal) competed for by distinguished workers in the field of public health; a gold medal conferred by the exposition of applied chemistry, recently held in Turin, and one of the four gold medals struck by the school of tropical medicine of Hamburg, on the occasion of its twenty-fifth anniversary.

THE Academy of Medicine, Paris, has awarded the Prince Albert of Monaco prize of 100,000 francs to Professors Hédon, of Montpellier, and Laguesse, of Lille, for their respective works on the internal secretion of the pancreas and the organization of scientific work.

THE council of the British Institution of Mining and Metallurgy has awarded its gold medal to Sir Robert Kotzé in recognition of his services to the mining industry, with special reference to his work on the dust problem in the mines of the Rand, and of his public work in promoting the development of the natural resources of the Union of South Africa.

CHARLES LALLEMAND has been elected president of the French Academy of Sciences.

SIR HENRY MIERS, F.R.S., vice-chancellor of the University of Manchester and former professor of mineralogy at Oxford University, has been elected a trustee of the British Museum in succession to the late Dr. W. Bateson.

PROFESSOR WILBUR A. NELSON, Virginia state geologist and head of the school of geology of the University of Virginia, has been appointed chairman of the advisory council of the United States board of surveys and maps.

DR. O. W. RICHARDSON, professor of physics at the University of London, has been elected president of the Physical Society, of England.

SIR JOHN DEWRANCE has been elected to succeed Professor T. Turner as president of the Institute of Metals, England. Sir Robert B. Dixon, Sir Thomas

Rose and Mr. W. Murray Morrison were elected vice-presidents.

Dr. R. E. M. Wheeler, director of the National Museum of Wales, has been appointed keeper, secretary and accounting officer of the London Museum, in succession to Mr. F. A. H. Oates, who has retired.

George P. Gray has resigned as chief of the division of chemistry of the Department of Agriculture of California, a position which he has held since the formation of the department in 1919.

Harry W. Titus has resigned the position of nutrition chemist and associate professor of animal nutrition with the New Mexico College of Agriculture and Mechanic Arts, to take a position as associate biological chemist, nutrition investigations, Bureau of Animal Industry, Beltsville, Md.

Dr. J. G. Lipman, dean of agriculture at Rutgers University, sailed for Europe on March 24, to attend a meeting of the executive committee of the International Society of Soil Science, to be held at Groningen, Holland, from April 2 to 7.

Dr. Arthur W. Gilbert, Massachusetts commissioner of agriculture, sailed on April 7 to attend a conference of the International Institute of Agriculture at Rome, on April 19, before the preparatory committee meeting to be held under the auspices of the League of Nations at Geneva.

Dean Franklin Moon, of the New York State College of Forestry, Syracuse University, has been appointed by Governor Alfred E. Smith as the representative for New York State at the International Forestry Conference to be held in Rome, Italy, beginning April 29 and ending May 5.

Professor H. H. Whetzel, of the department of plant pathology at Cornell University, and Dr. Fred J. Seaver, mycologist for the Missouri Botanical Garden, recently returned from a five weeks' mycological collecting trip in the Bermuda Islands.

Dr. George T. Moore, director of the Missouri Botanical Garden, has returned from a trip to Central America, having visited Cuba, Jamaica, Costa Rica, Honduras and Panama. Dr. Moore secured a number of additions to the garden's collections of tropical plants.

H. W. Krieger, curator of ethnology in the U. S. National Museum, has left for Alaska, where he is going under the auspices of the U. S. Bureau of Ethnology for the purpose of treating and restoring the totem poles of the National Monument at Kasaan, in southeastern Alaska.

Dr. L. W. McKeehan, of the Bell Telephone Laboratories, New York City, will give a series of three Bartol Research Foundation lectures on "Magnetostriction" before the Franklin Institute, Philadelphia, on April 13, 16 and 21.

Dr. C. F. Marvin, chief of the U. S. Weather Bureau, will lecture before the Franklin Institute on April 15 on the subject of "Solar Radiation and Weather Forecasting."

A. D. Little, of A. D. Little and Company, gave a public address on the subject "The Romance of Carbon" in connection with the seventy-first meeting of the American Chemical Society, which took place in Tulsa, Oklahoma, from April 5 to 9.

Dr. W. J. Thom, Jr., of the U. S. Geological Survey, recently completed a series of lectures at Princeton University on the geology of petroleum and coal.

Dr. John J. R. Macleod, professor of physiology at the University of Toronto, addressed the annual banquet of the Kansas City Academy of Medicine on February 5 on "Some Further Work on Insulin."

On March 20, Professor G. S. Brett, of the department of philosophy in the University of Toronto, delivered an address to the Royal Canadian Institute on the subject "The Dawn of Modern Science."

Dr. Charles P. Berkey, of the department of geology at Columbia University, recently gave lectures before the Geographic Society of Chicago, Northwestern University, the Universities of Wisconsin, Minnesota and Kansas and the Missouri School of Mines. Personal experience in two widely different fields of investigation formed the basis of these lectures—the explorations of the third Asiatic expedition in Central Asia and the applied geology of the Catskill aqueduct of New York City.

Dr. J. E. Ackert, of the Kansas State Agricultural College, addressed the Phi Sigma Society of the University of Nebraska, on March 17, on the subject, "Recent Developments in Medical Zoology."

Dr. George F. Kay, head of the department of geology in the State University of Iowa, and state geologist of Iowa, gave a lecture on "The Pleistocene Deposits of Iowa" to the staff and graduate students of the department of geology of Harvard University on March 15, and at Yale University on March 16.

Dr. E. F. Burton, of the department of physics at Toronto University, lectured at the University of Minnesota on March 30 on "The Physics of the Ultra-microscope: Its Structure and Use, and the Optical Properties of Suspended Particles and Colloidal Cells."

Dr. Thomas Buck Hines, in charge of the research work for Western Electro-Chemical Company and

formerly of the Chemical Warfare Service, died on February 10.

Sir Philip Watts, F.R.S., lately director of naval construction in the British Navy, died on March 15, at the age of seventy-nine years.

Professor Aimé Witz, an authority on internal-combustion engines and heat utilization, died on January 25, at Lille, France, in his seventy-seventh year. Professor Witz had taken a prominent part in electrical developments in France.

Charles Dufour, formerly director of the Parc Saint-Maur Observatory, has died.

The first American Health Congress will be held in Atlantic City from May 17 to 22, under the auspices of the National Health Council. The meeting will represent five years of achievement of the sixteen organizations forming the National Council. It will bring together health workers from all parts of the country, for the consideration of common problems. Among the speakers will be Sir Arthur Newsholme, founder of the ministry of health in England; Dr. C.-E. A. Winslow, president of the American Public Health Association; Dr. Clarence D. Selby, president of the Ohio State Medical Society; Dr. Ray Lyman Wilbur, president of Stanford University and past-president of the American Medical Association, and Dr. George E. Vincent, president of the Rockefeller Foundation.

Announcements of future meetings of the Institute of Medicine of Chicago include two lectures by Sir Arthur Newsholme, of London, on May 10 and 11, at the University of Chicago, with which the lectures have been arranged conjointly; Professor Friedrich Mueller, of Munich, Germany, in October, 1926; Dr. Francis W. Peabody, Boston, October 29, when the third annual joint meeting with the Society of Internal Medicine will be held, and the seventh Pasteur lecture, November 19, by Dr. Donald Van Slyke, of the Rockefeller Institute.

The third annual meeting of the South Carolina State Academy of Science was held recently at LeConte College, University of South Carolina. The morning session was opened by an address of welcome by Dr. A. C. Moore. The response was given by Dr. F. H. H. Calhoun, of Clemson College. At the business meeting the following officers were elected: *President,* Dr. A. C. Moore, of the University of South Carolina; *vice-president,* Dr. H. W. Barre, of Clemson; *permanent secretary and treasurer,* Dr. G. C. Bruce, of Winthrop; *council members,* Dr. Stephen Taber, of Carolina; Dr. R. H. Sullivan, of the United States Weather Bureau; Professor H. E. Sturgeon, of Presbyterian College. Seventy-five members were in attendance. The address of the retiring president, Dr. F. H. H. Calhoun, was on "The Religion of the Scientist."

On March 27, three hundred and seventy-five members and friends of the science organization of the New York City High Schools, the Association of Biology Teachers, the Chemistry Teachers' Club and the Physics Club, together with the Torrey Botanical Club, met at the second annual inter-science dinner at the Hotel Majestic. The toastmaster for the occasion was Professor James Kendall, of Columbia University. Dr. John Merle Coulter delivered the address on the topic "The History of Organic Evolution." Other speakers were Dr. John L. Tildsley, district superintendent in charge of high schools, and Dr. Joseph K. VanDenburg, of the board of examiners.

At the November meeting of the Peking Society of Natural History, Dr. Bernard E. Read, of the Peking Laboratory of Natural History, gave a talk on "The Medicinal Plants of China," illustrated by slides, specimens and pharmaceutical preparations. At the December meeting, Dr. A. W. Grabau gave a lecture on "Common Shells of the China Coast," illustrated by specimens and lantern slides. At a special meeting on December 30, Dr. H. J. Howard gave an account of his ten weeks with the Black Dragon River bandits.

Seven meetings to promote scientific work are being held this year in Russia at the call of the People's Commissariat of Education of the Russian Socialist Federated Soviet Republic. Botanists met in Moscow during January, while this month that city is to be the scene of a conference of physicists. In May a congress of physiologists is to be held in Leningrad, while for the latter half of the year congresses of archeologists and museum specialists, of geologists and of naturalists are scheduled.

The Italian Association of Pure and Applied Chemistry is to hold the second national meeting of Pure and Applied Chemistry at Palermo from May 23 to June 2. One of the features of the meeting will be the celebration of the centenary of the birth of Stanislao Cannizzaro.

The Harvard University summer school of field geology, endowed in 1908 by Mr. Robert W. Sayles, will this coming year be held in the vicinity of the Adirondack Mountains instead of in the Rocky Mountains as on former occasions. The school will be in session from July 6 to August 9 and opportunity will be afforded for the investigation of the geology along the eastern side of the Adirondack Mountains and in the Champlain Valley as well as in the Green Moun-

tains of Vermont. Headquarters will be established in the vicinity of Ticonderoga. The school will be conducted under the direction of Professor Allyn C. Swinnerton, of Antioch College. Full details may be obtained by addressing either Professor Swinnerton at Yellow Springs, Ohio, or Professor P. E. Raymond at Harvard University, Cambridge, Mass.

AT the meeting of the executive committee of the American Museum of Natural History, held on March 17, the following elections to honorary membership were made: William Douglas Burden was elected an associate benefactor in recognition of his support of an expedition to the Island of Komodo. Howard Russell Butler was elected an honorary fellow in appreciation of his contributions to the popularization of astronomy through his unique paintings of solar eclipses and other astronomical paintings. Kunwar Dillipat Shah Rai Bhadur was elected an honorary life member in recognition of his assistance to the Faunthorpe-Vernay expedition in India. Captain J. B. L. Noel was elected an honorary life member in appreciation of his explorations in the Himalayas and his remarkable ascent of Mount Everest. Dr. Fordyce St. John was elected a life member in recognition of his contributions to the science of surgery and medicine.

ACCORDING to a cable to the New York *World*, the Academia dei Lincei, Rome, will soon be dissolved because in the opinion of the cabinet the institution has become a hotbed of anti-Fascist sedition. For similar reasons it is stated that the Italian Society for Scientific Progress and other cultural organizations are to be repressed. It is also reported that the Italian Philosophical Congress meeting at the University of Milan has been dispersed by government order.

BY the will of the late Mrs. Stephen V. Harkness, of New York, the American Museum of Natural History and the New York Zoological Society will each receive $1,000,000. Other large bequests were made to Columbia, Yale and other institutions, but these were largely anticipated by gifts made during her lifetime.

THE appraisal of the estate of Henry R. Towne, engineer, founder and recent head of the Yale-Towne Manufacturing Company, filed on March 31, shows the bequest established in his will to maintain "Museums of the Peaceful Arts in the City of New York" is valued at $2,616,211.

THE following gifts have been announced by New York University: R. T. Crane, Jr., of Chicago, has for the second year given $4,000 for the study of anaphylaxis. Two anonymous gifts—one of $10,000 and one of $5,000—have been received. The first gift was made through Dr. George Stewart for the expenses of the department of surgery for the current year. The $5,000 was received through Professor John M. Wheeler for experimental work in ophthalmology.

IT is planned to begin building operations on the new Wilmer Institute of the Johns Hopkins University in June.

THE National Geographic Society has appropriated $5,000 for the purchase of 1,000 acres of the proposed Shenandoah National Park, which will be presented to the government for inclusion in that area. This donation is the largest single contribution made during the Washington campaign. The donation was made, it was announced, upon the recommendation of the chairman of the society's research committee, Dr. Frederick V. Coville.

HARVARD UNIVERSITY has acquired approximately 125,000 feet of land fronting on Centre Street, Jamaica Plain, and adjoining the Arnold Arboretum. This land is to be used in connection with the work of the arboretum.

THE annual report of the committee in charge of the American Type Culture Collection shows that the available cultures have increased from 175 to 722 during the period February 1 to December 15, 1925, including 69 moulds and 122 yeasts. A total of 360 orders has been filled, involving the sending of 1,540 cultures to 240 persons and institutions. A temporary list of cultures is available. A printed catalogue is planned for the near future. Communications should be sent to The American Type Culture Collection, John McCormick Institute for Infectious Diseases, 637 S. Wood Street, Chicago, Illinois.

ACCORDING to the *Scientific Worker*, England, the Royal Agricultural Society has taken the step of setting up a committee of scientists to collect and collate the results of agricultural research work. This committee, which includes Sir John Russell, Sir John McFadyean, Dr. Crowther, Mr. Orwin and Mr. Engledow, proposes to publish annually, in language intelligible to the practical agriculturist, a summary of the results of agricultural research work carried out in all parts of the world of immediate or future importance, as well as an account of work proved definitely negative. This experiment in publication is on the lines followed by research associations in other industries. It will supplement and possibly supplant the pamphlets which emanate from the Ministry of Agriculture and Fisheries, many of which are put aside and lost owing to the way in which they are issued.

THE Russian government announces that the geological committee of the Supreme Economic Council formed during 1925 no less than 215 scientific expedi-

ions. The main achievements are reported to be as follows: Discovery of rich lead beds in the trans-Baikal region, exploration and discovery of gold fields in the Aldan region of Siberia, and finding of important strata of coal on Sakhalin Island. The expeditions will continue their researches and explorations during 1926, the government having allotted $1,500,000 for this purpose.

MINISTER OF AGRICULTURE GUINESS has made public further particulars regarding the British government's agricultural policy. The most important item of the program is an additional grant of about $2,-000,000 for agricultural education and research during the coming five years, of which amount it is proposed to spend about $250,000 on foot-and-mouth disease research and about $60,000 on veterinary education and research. A new bureau is to be established to deal with marketing and cooperation. It is also proposed to establish new farm institutions for research work.

ACCORDING to the *Journal* of the American Medical Association, Representative Woodruff, of Michigan, has introduced a bill in the house of representatives which would establish, in the department of the interior, a bureau of medical research, the function of which would be to investigate physiologic processes; to devise means for controlling the bodily processes, and to determine the physical, chemical and biologic properties of materials where this would be advantageous to medical science. The bill provides for a director of the bureau, to be appointed by the president at a salary of $15,000, an assistant director at $10,000 and such other employees as the director should decide, these appointments to be made under civil service rules. There would be also a visiting committee of five prominent members of scientific societies, not in the employ of the government, to serve without compensation. Mr. Woodruff's bill would authorize the director to negotiate for not more than 100 acres of land near the city of Washington at not more than $2,000 an acre, and to draw plans for suitable buildings to cost not more than $1,000,000. The director of the bureau of medical research, according to this bill, shall make plans and submit estimates to the director of the budget on a basis of spending about $550,000 in 1927.

AT the request of the International Committee on Intellectual Cooperation of the League of Nations, the American Library Association has compiled a list of the forty outstanding books published in the United States during the calendar year 1924. This is in pursuance of the plan of the League of Nations to publish yearly a list of the 600 most worth-while books in all countries on all subjects. Countries publishing 10,000 or more new books each year are entitled to name the maximum quota of forty. Of the forty just named, five are in the field of natural science as follows: Charles William Beebe, "Galapagos" (Putnam); Ellsworth Huntington, "The Character of Races" (Scribner); George Grant MacCurdy, "Human Origins," 2 vols. (Appleton); Edmund Vincent Cowdry, "General Cytology" (Univ. of Chicago Press); Vernon Kellogg, "Evolution" (Appleton).

CORRECTION. In Dr. Wheeler P. Davey's review of "The Natural History of Crystals" (SCIENCE, 1627, LXIII, 1926) the author's name was incorrectly given as A. E. Hutton. The correct spelling is A. E. Tutton.

UNIVERSITY AND EDUCATIONAL NOTES

THE New York Zoological Society, Vassar College, Williams College and Teachers College, Columbia University, will each receive $300,000 by the will of the late Mrs. Mary Clark Thompson, of New York.

THE residuary estate of the late Artemas Ward, which has been left to Harvard University, is estimated to have a present value of $4,000,000.

THE General Education Board has given to Richmond University $100,000 for a science hall to replace that destroyed by fire a few months ago. It is planned to raise a fund of $400,000 for this building.

NORTHWESTERN UNIVERSITY has announced plans to build a large science hall on the shore of Lake Michigan at Superior Street as part of the downtown campus.

AMONG those who will give courses in the summer quarter at Stanford University are Professor A. R. Moore, of the department of physiology at Rutgers University, and Professor N. H. Furman, of the department of chemistry at Princeton University.

L. C. BAGBY has been appointed assistant professor of mathematics at the University of South Dakota.

DR. ALBERT WIGAND has been appointed professor of physics and meteorology at the Landwirtschaftliche Hochschule, Hohenheim-Stuttgart. He is also in charge of the seismological observatory and meteorological station at Hohenheim.

THE title of professor of physiology in the university has been conferred on Dr. J. S. Edkins, in respect of the post held by him at Bedford College.

DR. H. R. BRITON-JONES, mycologist at the Agricultural and Horticultural Research Station of the University of Bristol, has been appointed professor of mycology at the Imperial College of Tropical Agriculture, in succession to Professor Ashby.

DISCUSSION AND CORRESPONDENCE

DISTRIBUTION OF INTENSITY IN THE FOCAL SPOT OF AN X-RAY TUBE

In a recent article on the apparent shape of X-ray lines, Mr. F. K. Richtmyer[1] describes experiments showing that the distribution of X-ray brightness over the focal spot of an X-ray tube is not uniform. He suggests that the non-uniformity is due to space charge effects and shape of target. Though the effect may be partly due to these causes, we have evidence that, at least in tubes using a Coolidge filament, the chief cause is quite different.

During our spectroscopic work, we have had occasion to investigate the distribution of intensity over the focal spot. For this purpose we took X-ray pin-hole photographs of the face of the target of a tube using a Coolidge filament. The plane of the target was normal to the cathode stream, and the photographs were taken in a direction as nearly normal to the face of the target as the shape of the tube would permit. Under these circumstances, if the exposures were so short that only the most intense rays were registered on the plate, the images of the focal spot were spiral in form and exactly what would be expected if the focal spot was a nearly orthogonal projection of the filament on the face of the target. In view of the small gaps between the spirals of the filament and the diameter of the wire, the sharpness of the images was surprising. When the photographs were taken through a narrow slit instead of a pin-hole, and in a direction making a small angle with the face of the target, the images contained striations running parallel to the jaws of the slit, exactly as was to be expected from the spiral nature of the focal spot. In using two very narrow slits in the manner described by Mr. Richtmyer, we find it of great advantage to have the line of slits fall on the most intense part of the focal spot as shown by these photographs.

In discussing the effect of slit width on the width of spectral lines, Mr. Richtmyer does not state how far his ionization chamber was from the crystal. Professor H. S. Uhler[2] has shown that, under certain rather rigorous conditions, when two very short slits of equal width are used, there is a portion of the monochromatic beam reflected from the crystal the width of which can not be greater than the width of the slits. This is only strictly true if the depth of penetration in the crystal is negligible and the crystal is a perfectly selective reflector. A finite depth of penetration in the crystal would tend to broaden the cross section of the portion considered, but probably by the same amount throughout its length. If there is a finite range of angles over which the crystal can reflect a given wave length, the reflected beam will be divergent even in Uhler's region of constant cross section. We have found that the $K\alpha_1$ line of silver reflected from a very perfect calcite crystal is broader when photographed in the portions of this region more remote from the crystal. Prof. Siegbahn[3] discusses the possibility of a finite range of reflection angles for a single wave length due to refraction in the crystal. Though we have not yet subjected the matter to a thorough investigation, the order of magnitude of this broadening is about what would be expected from the geometry of our spectrometer and the index of refraction of calcite, if this finite range of reflection angles really exists.

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D. Cooksey

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[1] *Phys. Rev.*, 26, p. 727, Dec., 1925.

[2] *Phys. Rev.*, 11, p. 17, 1918.

[3] Siegbahn, "The Spectroscopy of X-rays," English Trans. p. 23.

CO BANDS

In a recent article (*Astrophysical Journal*, 62, p. 145, 1925) I reported the discovery of three new band systems which I attributed to nitrogen and called the second negative and the fifth and seventh positive bands of nitrogen. I have recently received letters from Professor O. S. Duffendack, of the University of Michigan, and from Professor Raymond T. Birge, of the University of California, calling my attention to the fact that these band systems belong to carbon and are probably due to CO. Duffendack and Fox find them to appear very strongly in the spectra of low voltage arcs in CO and are measuring their excitation potentials. Birge points out that the seventh positive bands are a portion of the fourth positive bands of carbon that have recently been obtained as absorption bands of CO at ordinary temperatures by Leifson (*Astrophysical Journal*, in press), while the second negative bands fit into his scheme of energy levels for the ionized CO molecule (*Nature*, in press). The fifth positive bands have rather complicated fine structure and their exact origin is still in doubt.

The very close agreement of the vibrational shifts in these bands and in the first negative and second and fourth positive bands of nitrogen is apparent from tables III, VII and VIII of my article. In the first and second negative systems the frequency differences between corresponding vibrational levels differ only one half to one per cent., while in the second, fourth and fifth positive bands the frequency differences are identical within the limits of experimental error. This is further evidence in support of the view that the structure of the CO molecule is very similar to that of the N_2 molecule. From a

nsideration of the masses of the nitrogen and CO olecules one would expect a difference of two per nt. for the vibrational shifts of corresponding stems. It would seem that the differences in the rces in the two molecules is such as to compensate r the differences in masses.

The presence of CO in my apparatus was probably e to its evolution from the nickel cylinder upon hich the gauze was mounted. This nickel must ve contained nickel carbonyl, which breaks down at gh temperatures and yields CO. Facilities for the mplete outgassing of this tube were not available.

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ANOTHER LUMINOUS SPIDER

A NOTE on "A Luminous Spider," published by me SCIENCE, August 21, 1925, it seems has been copied the London *Sphere,* and another observation has een reported in a letter from Mr. C. H. Bompas, ishops Stratford, Herts, England, which reads:

I have read your note on a phosphorescent spider from urma in the *Sphere.*

As you are presumably interested in such things you ay like to know that I have seen such a spider at Shilng, in Assam.

The spider is truly phosphorescent and switches on its ght when frightened. It is some time since I saw one, t my recollection is that the light came from six or ght spots under the abdomen.

The one I saw was in the middle of a bush and when pproached or shaken glowed more brightly, no doubt a means of defense.

The locality from which this second occurrence is eported is about one hundred miles from the place f my observation in Burma. While the observation iffers in many respects, it is, I think, well worth ecording.

BARNUM BROWN

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THE METHODS OF THE FUNDAMENTALISTS

DR. KEEN'S experience with the "constructive memry" of the Rev. W. B. Riley, D.D. (SCIENCE, Decemer 11, 1925, p. 543) just about matches a more recent ne of my own with another important Fundamenlist.

My attention was called to an article, "The Bible nd Evolution," in *The Herald of Christ's Kingdom* September 15, 1925, p. 275) in which there appears long quotation from Darwin's "Life," which examiation proves to be made up by combining portions of two paragraphs that in Darwin's text (Vol. 1, pp. 277 and 282) stand four and one half pages apart. In this "quotation," moreover, Darwin's words (p. 282) "I deserve to be called a Theist" appear as "I deserved to be called an atheist"—and the usual moral is drawn.

I wrote the editors of *The Herald of Christ's Kingdom,* setting forth these facts, with all the proper references. I also wrote that their article contains, along with this, a great many more similar oversights; and I offered, since they proposed to bring out a reprint of their "special evolution number," to send them a list of a dozen or twenty of these errors, which I agreed to check up carefully, provided they would agree not to reprint in their new edition any fact on my list which they themselves could not verify, and would withdraw the spurious quotation.

They rejected my offer. This is the sort of evidence that is now being presented to state legislators to get laws forbidding the teaching of evolution. Moreover, these people are not anywhere in the mountains of Tennessee, but at 177 Prospect Place, Brooklyn, New York.

E. T. BREWSTER

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SCIENTIFIC BOOKS

Left-handedness. By BEAUFORT SIMS PARSON. New York, Macmillan, 1924. Pp. 185.

THE fundamental differences that determine right- and left-handedness have probably not been discovered by Mr. Parson, and yet his experimental results are very suggestive. He calls attention to the fact, so often observed, that right-handed persons are usually right-eyed. Ordinarily the right eye has better vision. This is usually the eye selected for monocular use with microscope or rifle. But the author points out a more important meaning of the term, right-eyedness, which is this.

If we fixate a distant object with both eyes, a near object gives us a double image. If, maintaining our fixation, we grasp the near object and so move it as to bring its image on the fovea, it is usually upon the fovea of the right eye that the image falls. This means that when we point to an object we place the pointing finger along the line of vision of the right eye. Were we to direct both eyes toward the finger, the right eye would remain stationary and the left would move. In this sense the right eye is dominant. In reaching for an object that casts double images, it is stimulation of the right eye that determines our movement.

As aiming is done along the right eye's line of vision, the right hand is more likely than the left to

be employed, for it has a shorter distance to travel. Thus, the author believes, the right hand receives more education and gradually assumes predominance.

Mr. Parson's apparatus for determining right- and left-eyedness is inadequately described in the book, but consists of a stereoscope face-piece attached to an enclosed box containing shutters by means of which the preferential use of the right or left eye is determined. This is called a "manuscope," a name as unwarranted as the author's statement that "eyedness is cause and handedness effect." There is no measure given of the reliability of the following results, obtained from the examination of school children of Elizabeth, N. J.:

604 subjects were right-handed and right-eyed
225 subjects were right-handed and left-eyed
4 subjects were left-handed and right-eyed
32 subjects were left-handed and left-eyed

The subject's own statement was taken as the criterion of right- and left-handedness. Handedness corresponded to eyedness in 74 per cent. of the cases. But we may analyze the author's results as follows:

If right-handed, the chances that a subject will be right-eyed are 72 in 100.

If left-handed, the chances that a subject will be left-eyed are 89 in 100.

If right-eyed, the chances that a subject will be right-handed are 99.3 in 100.

If left-eyed, the chances that a subject will be left-handed are 12 in 100.

Mr. Parson's hypothesis could be reversed and it would work quite as well. He could have assumed an original right-handedness and have derived his right-eyedness. An originally greater activity of the right arm would introduce the infant's hand more frequently into the right than into the left eye's line of vision. Thus more habits would be built up about foveal stimulation of the right eye, and right-eyedness would result from original right-handedness. All that is needed to disprove the author's thesis that right-handedness is derived from right-eyedness is a left-handed baby congenitally blind in the left eye. It would be well to look for such a case.

Stevenson Smith

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SPECIAL ARTICLES

QUESTIONNAIRE ON CERTAIN FACTS BEARING ON THE THEORY OF SEXUALITY AND CHROMOSOME CONSTITUTION

In order to obtain a clearer understanding of the phenomena of sexuality the writer has put the following questions to himself while attempting to arrive at a proper theory of sex and sex determination. They may be of use to others who may be wandering about in a slough of despond if not in a fool's paradise, vainly attempting to satisfy their minds that the hypothesis of homozygous and heterozygous sex potentialities or "sex chromosomes," still so naïvely held, is the explanation of the nature and cause of sexuality and sexual states, when at best it could never be more than an explanation of unisexuality and dieciousness as contrasted with hermaphroditism and bisporangiateness. Certainly any one intent on finding a way to the truth must be confused if he still entertains such an hypothesis after he has become aware of the fact that organisms, both plant and animal, with allosomes nevertheless can be reversed the female to the male and the male to the female condition in spite of the fact that one sex in the given case has a homomorphic set of allosomes and the other a heteromorphic set.

(1) If maleness and femaleness are the result of and conditioned on the presence of specific sex genes or potentialities, how does it happen that a cell lineage (either with haploid or diploid chromosome complements) without a change of chromosome content without aggregation (fertilization) or segregation (reduction) can nevertheless pass successively from (1) a neutral state, to (2) a female state, to (3) a neutral state, to (4) a male state?

(2) Why are the staminate and carpellate branches of various monecious plants just as fixed in their sex and just as extremely dimorphic as they are in diecious plants?

(3) If sexuality is a matter of hereditary factors either simple or multiple, why did the higher plants with an alternation of generations evolve a condition in which sex segregation or sex determination never follow reduction, and in which sex determination usually (except in the case of the rather rare diecious plants) does not follow promptly on fertilization, but male and female determinations take place during the vegetative period of the diploid sporophyte?

(4) If in some organisms, with allosomes, in which there is a homozygous condition in one sex and a heterozygous condition in the other, these conditions are regarded as the cause of sex determination, sex production or sex stability, how does it come about that not only the heterozygous sex can be reversed to the opposite condition but the assumed homozygous sex can also be reversed, sometimes as readily as the heterozygous one? How does the homozygousness in relation to sex change to heterozygousness?

(5) If it is assumed that in the heterozygous individual, in respect to allosomes, one allosome was dominant over the other in determining sex and then, in case of sex reversal, necessarily becomes recessive

through some special functional state brought about by the environment, how do we know that a similar functional state was not present and responsible for the determination of the original sexual state?

(6) If allosomes have such a profound influence in the diploid condition, whether in homozygous or heterozygous association, as has recently been generally assumed, how does it come about that they are entirely impotent to influence the sexual state whether secondary or primary in the haploid cell generations following reduction, when we know that the haploid and diploid conditions do not interfere with either gametophytic or sporophytic expressions, but that either a haploid or diploid state gives a normal or nearly normal gametophyte and also a normal or nearly normal sporophyte?

(7) What is the cause or factorial mechanism if any that determines the sex of a specific region in diploid and haploid hermaphrodites and in diploid and haploid, bisporangiate sporophytes?

(8) Why are haploid unisexual gametophytes and diploid diecious sporophytes without allosomes often just as fixed in the given sexual state and just as dimorphic as similar gametophytes and sporophytes with clearly recognized allosomes?

(9) Why are organisms with allosomes often as easily sex-reversible as organisms that have no such specialized chromosomes?

(10) If in Sphaerocarpus the allosomes are assumed to be the direct cause (factorial hereditary cause) of maleness and femaleness in the gametophytes with which they are associated, how does it happen that when they are together no dominance is shown, but the resulting generation is completely neutral and nonsexual, when in other cases such a heteromorphic pair of chromosomes is assumed to have the one a dominant factor or group of factors and the other a recessive factor or group of factors and to be all-potent in bringing about sexual states in the diploid condition?

(11) If hereditary constitution is responsible for the sex of identical twins, how does it come about that in the diecious Arisaema triphyllum, while the twins are still connected by a bridge of living tissue one can nevertheless be induced to become a male and the other a female?

(12) If dieciousness in the higher plants is caused by segregating "sex chromosomes" or allosomes or by some other possible Mendelian factorial condition, how can the facts be explained that in the diecious Acer platanoides, for example, quite frequently one or more flowers, flower clusters or branches on a staminate tree will show sex reversal to the female condition and in the same way sex reversal will be shown on a carpellate tree to the male condition, and that not only will the sex reversal in either case bring forth normal development of the opposite set of sporophyll on the tree but will at the same time induce reciprocal vestigial development of the sporophylls characteristic of the individual as a whole, so that in the reversed parts the carpellate tree will have vestigial gynecia and the staminate tree vestigial stamens?

(13) How can any theory of sex based on the idea of male and female determiners or chromosomes explain the fact that frequently in Acer saccharinum, a diecious species, certain branches will nevertheless produce first carpellate flowers, with stamen vestiges, later with further growth, staminate flowers with carpel vestiges, and still later carpellate flowers again, also with stamen vestiges?

(14) If any factorial basis is assumed to explain the dieciousness of Morus alba, how can the fact be explained that a staminate tree sometimes produces a branch which for years bears both carpellate and staminate catkins and in addition bisporangiate catkins, while the individual as a whole continues to be staminate, when we know that the carpellate plant is also "heterozygous for sex" and frequently produces similar branches?

(15) What convincing evidence is there to show that allosomes are not merely the results of sexuality rather than the cause of it, and that they follow the sex rather than determine and control it; and further, what definite evidence do we have to show that sex determination is not always physiological and sex stability or persistency merely a phenomenon of differentiation?

John H. Schaffner

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WHY DO CILIATED ANIMALS ROTATE COUNTER-CLOCKWISE WHILE SWIMMING?

While studying the development of certain prosobranch gasteropods several years ago three distinct phases of their normal swarming reactions were observed which so far as I can learn have never been recorded.

The recent work of Grave and Schmitt, Haywood, Wyman and others on the physiology of ciliary action and the histology of the cilium leads me to record these observations and other studies suggested by them in the hope that some worker in this field will interpret the phenomena.

One can not observe a group of these gasteropod larvae just before swarming begins, while they are still surrounded by the protecting jelly-like albumen in which the eggs were laid, within or without a capsule, without being impressed with the great

energy of their locomotion. Since the early gastrula stages they have been moving, a few cilia breaking out from certain epidermal cells very early, while the greater part of the yolk is present and well before the mouth appears. This motion increases hourly with the age of the veliger, but even when it has reached its greatest degree of activity in the turmoil of an egg-mass just before it finally breaks to let the veligers fare forth in the swarming of the new generation, careful study will show that the apparent complexity of it can be reduced to the same phases that marked the motion of the gastrula. These are:

(1) A counter-clockwise rotation on the polar axis while swimming.

(2) Swimming in clockwise circles.

(3) Somersaulting backward; that is, toward the aboral side, while lying on the animal's left side.

Finding this behavior in all the common prosobranch veligers in the Woods Hole region the query naturally arose, "How does the behavior of snail veligers differ from that of other ciliated larvae?"

A study of ciliated and flagellate protozoa, the larvae of sponges, coelenterata, echinoderms, lamellibranch mollusks and annelids resulted in the rather surprising discovery: (1) that they all show a counter-clockwise rotation on the polar axis while swimming, (2) that in fourteen of the twenty-six forms studied swimming in clockwise circles was observed, (3) that in nine forms, somersaulting toward the aboral side was observed. No somersaulting movements were recorded for two ciliate protozoa studied—a *Paramecium* and a *Vorticella* species, nor for the seven flagellate genera, *Euglena, Ceratium, Phacus, Synura, Volvox, Glenodinium* and *Pandorina;* nor for the larvae of *Gonionemus* and *Hydractinia,* and the lamellibranchs, *Mytilis* and *Cumingia;* nor for the annelids *Arenicola* and *Amphitrite.* Yet of course this movement may occur in all these forms.

Likewise, none of the protozoa nor the hydrozoan larvae mentioned were observed to swim in clockwise circles, yet that behavior may occur, also.

Interesting variations of these phases of behavior are to be seen in *Nereis* and the lamellibranchs mentioned. But the simple phases are so generally found throughout this wide range of phyla that it would seem that we have here another evidence of the fact that behavior is as fixed a thing in the line of evolutionary descent as structure.

And yet the distinction implied here is a superficial one. For behavior is merely an expression of structure. This must be true throughout the whole range of living things. For the biologist, the meaning of the common expression "The Freedom of the Will" must be limited. For the organization and hence interrelation of the nerve cells in the brain ultimately rules.

That the direction of the beat of the cilium is inherited through evolutionary descent is indicated by an observation rather frequently made during a study of the development of prosobranch gasteropods.

As one looks at the spire of a marine snail shell in polar view, the coils of the shell turn clockwise. But perhaps one shell in a thousand of any given species turns in the opposite direction. This occurred because that snail's shell-gland grew on the opposite side of its body from the normal position. A study of its anatomy would show that all its organs occupy just the opposite positions from the normal ones.

Likewise, in the study of veligers of these forms, one sees very rarely a larva which rotates clockwise on its polar axis, swims in counter-clockwise circles and lies on its right side while it somersaults toward the aboral side.

Careful study of such an individual shows that each of its asymmetrically placed organs occupies a position which is just the reverse of the normal; in short, the animal is a mirrored image of a normal animal, so far as the location of its organs is concerned. Going back one step further, students of the embryology of the prosobranchs tell us that during the earliest cleavages of the egg the first polar furrow turns to the left in cases of "inverse symmetry" instead of to the right.[1] Hence, the direction of the beat of the cilia is determined at least as early as the first cleavages of the egg.

But since the cleavage program is determined by the cytoplasmic organization of the fertilized but unsegmented egg, we must conclude that the swimming behavior of ciliated larvae is as fixed in its inheritance as for instance the polar axis of the body. This conclusion is further indicated by the fact that the protozoa which also show this typical ciliary behavior do not segment as eggs do. Hence, cytoplasmic organization must determine the distribution and the plane of vibration of cilia, and of flagella.

But Conklin in his study of Ascidian embryology found that the definite organization of the cytoplasm occurs only after the disintegration of the nuclear membrane and the consequent distribution of nuclear material throughout the cytoplasm. And since the nucleus is built up from the chromatin supplied by sperm and egg, we must go still further back to the organization of the chromosomes for the source of this inherited behavior.

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[1] Crampton, H. E., "Reversal of Cleavage in a Sinistral Gastropod," Ann. N. Y. Ac. VIII, 1894.